Current Icing Product (CIP) Severity

Part I - Mission Connection

Product Description

The Current Icing Product (CIP) Severity is an automatically-generated index of icing severity developed by the In-Flight Icing Product Development Team sponsored by the Federal Aviation Administration's Aviation Weather Research Program. CIP Severity is scheduled to become an official National Weather Service product in December 2006.

The CIP Severity algorithm is rooted in cloud physics principles that have been applied in practical forecasting of icing Severity for research aircraft for nearly a decade. These principles and the resulting methods have also been applied to studies of icing incidents and accidents, as well as daily assessment of icing environments associated with icing PIREPs over the United States and Canada at all times of the year.

Through this process, the CIP developers gained considerable experience in applying these principles, learning what information can be gleaned from operationally available datasets, their relevance to specific icing environments and the confidence one can have in the information they provide. The result of this is a physically based technique that diagnoses the Severity of the meteorological icing environment via a balanced integration of information extracted from each data source. This information is then translated into a categorical icing Severity index that is designed to cover a wide range of aircraft and provide information to users that is relevant to decision processes related to in-flight icing.

The CIP Severity algorithm combines satellite, radar, surface, lightning and pilot report observations, as well as the icing potential and supercooled large droplet output, with model output to create a weighted consensus estimation of the meteorological severity of the icing environment in terms of an assessment of the liquid water content, drop size and temperature.

Purpose

The CIP Severity suite of products was developed to fill an outstanding need. The original CIP, fielded in 2002 and still in use today, was developed to produce "icing potential." However, FAA regulations are tied to icing severity categories, such as light, moderate and severe. The CIP Severity product provides new icing severity output. Another improvement in the CIP Severity suite compared to the original CIP is that the general (total) icing potential output has been recalibrated to give icing probability values. Probability is a more suitable metric for those who must make critical go/no-go decisions.

This product is part of a larger effort to support the NWS Strategic Plan and its goal to provide graphical weather products.

Product Availability and Transmission Schedule

When the CIP Severity product becomes an operational NWS product, it will be available in GRIB format at both 20 km and 40 km horizontal resolution over the conterminous United States and adjacent coastal waters (CONUS). The product set will be produced hourly in tandem with the NCEP Rapid Update Model (RUC).

<u>Audience</u>

The CIP Severity output is intended for both high-volume users of NWS forecast information (GRIB), as well as individuals who may wish to view the data on a webpage maintained by the NWS or a weather product vendor. The CIP Severity is meant to be used as a supplement, not as a substitute for the icing data contained in AIRMETs and SIGMETs. When it becomes an official NWS product it may be restricted for use by operational meteorologists and trained dispatchers only.

<u>Web Interface</u>

During the experimental phase, the CIP Severity can be visualized at the following URL: http://weather.aero/icing/. An example of the CIP Severity output is shown below.

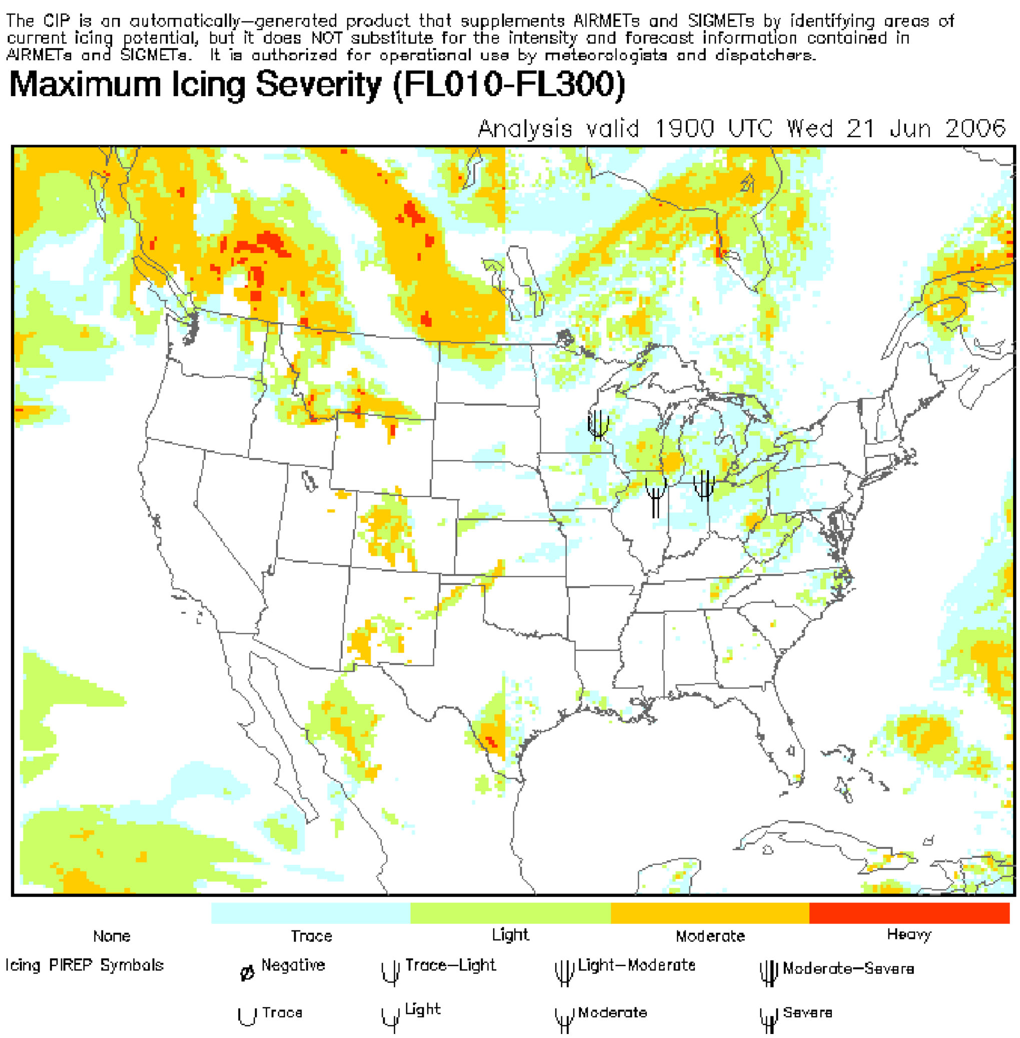

Figure 1: CIP Severity Composite Image Valid 1900 UTC 21 June 2006

Feedback Method

The NWS is always seeking to improve the representation of our products based on user feedback. Comments regarding the experimental CIP Severity output should be submitted by clicking on the "submit" link at the top of the http://weather.aero/icing/ page.

Part II - Technical Description

The final severity output will be a value between 0.0 and 1.0, with larger values indicating higher expected severity. To translate the output into meaningful categories for users, the output was compared to thousands of positive and negative icing PIREPs over a three month period where a large variety of icing situations occurred and all of the icing scenarios were well represented.

The following categorical thresholds were chosen:

No Icing: < 0.01
0.01 ≤ Trace ≤ 0.175
0.175 < Light ≤ 0.375
0.375 < Moderate ≤ 0.7
0.7 < Heavy

The severity value calculated is the expected representative icing severity for the grid box for the range of aircraft in the development and verification data set. This brings up an important point regarding the applicability of a single severity index to the wide variety of aircraft that are flying.

There has been considerable discussion regarding severity and aircraft type. It is obvious that different types of aircraft can experience different severities of icing in the same atmospheric environments. Severity definitions are currently pilot based so they naturally are a function of the aircraft type, flight phase (takeoff/landing, cruise, etc.), configuration and the pilot's experience and perception of the icing hazard. It is a goal of the icing community to come up with accurate definitions of the icing environment in terms of the relevant parameters – liquid water content, drop size and temperature – and allow calculation of an aircraft specific Severity from those. To date, however, no single data source or system has accomplished this adequately.

It is the goal of CIP Severity to glean severity relevant information from each data source available to it, weigh that information appropriately for the icing situation at hand, then create a weighted consensus estimation of the meteorological severity of the icing environment in terms of an assessment of the liquid water content, drop size and temperature. This information can be roughly translated into an ice accretion rate, given an assumed aircraft speed and configuration. Ice accretion rates can be fairly accurately calculated for a range of 9 airfoil sections, but the accretion on a whole aircraft is uncertain. Furthermore, the relationship between accretion and resulting performance degradation is not well understood and this is further confounded by the fact that the history of the accretion is important: how much ice (and location and texture) is already on the aircraft when it encounters an icing condition greatly affects the response to that condition.

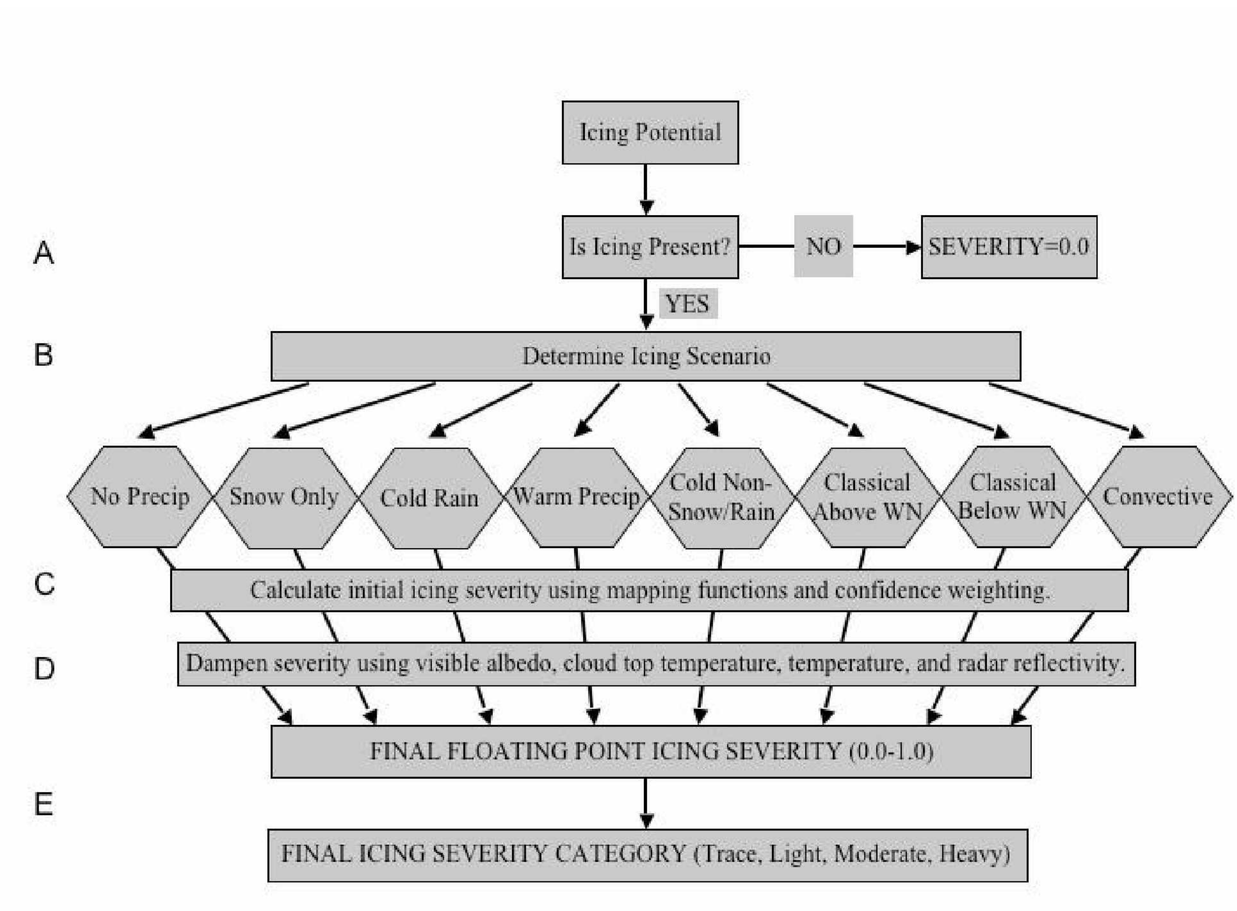

Figure 2: Flowchart of the CIP Severity Process

<u>Description of Input Data Sets</u>

This section describes the datasets used in the CIP Severity algorithm and the fields that are of interest from each one.

(1) Model

The operational version of the Rapid Update Cycle (RUC) model is used to define the algorithm domain and grid spacing (grid boxes are approximately 20 km by 20km). Both the pressure and hybrid level output files are ingested. CIP attempts to use three hour forecasts valid at the CIP diagnosis time whenever possible, but if those are not available it will look for six, nine, and twelve hour forecasts, respectively. The pressure files provide temperature, geopotential height, relative humidity, and vertical velocity every 25mb. The hybridB files provide five condensate species (cloud water, rain water, cloud ice, graupel, and snow) which are interpolated to the 25mb pressure levels.

(2) Satellite

The satellite data are provided by GOES10 and 12. The data from the two satellites are stitched together then mapped to the model grid. The fields used are the visible reflectance (channel 1), longwave infrared (channel 4), and the difference between the short and longwave infrared (channel 2 – channel 4). Shortwave reflectance is derived from the channel 2 data, and the solar zenith angle is also calculated for each grid point.

(3) METARs

Surface observations provide information on cloud cover, ceiling height, precipitation occurrence and its type. The observations are mapped to the model grid using a concentric circles approach. Initially, CIP searches for ceiling and precipitation information from stations within 20 km of the center of a grid box. If appropriate information is not found within this radius, the circle is expanded until such information is found, out to a maximum radius of 125 km, if necessary. A complex hierarchical scheme based on the observational capabilities of each station is used in the determination of precipitation type.

(4) PIREPs

Pilot reports of icing severity from the previous two hours are used to determine a consensus Severity and a weighting factor for each grid box. The spatial and temporal distance of the PIREP from a particular grid point determines the relevance of the PIREP information.

(5) Radar

Radar data are supplied via a mosaic of composite NEXRAD reflectivity with 4 km spacing over the CONUS. Values are available in 5 dBZ increments, starting at minimum reflectivity of 5 dBZ. The Severity algorithm uses the 25th and 75th percentiles of the array of reflectivity values found within each model grid box. They are also used to define scenarios by identifying areas of precipitation that are not reported by the METARs.

(6) Lightning

Lightning data are provided by the National Lightning Detection Network. This dataset provides the location of all lightning strikes over the CONUS and is updated every minute. Strikes from the fifteen minutes before the top of the hour are first used to identify the icing situation as “deep convection”. The number of strikes within a radius of the center of each grid box is later used in the Severity calculation.